ACCELERATING COLOR CONVERSION METHODS IN THE CONTEXT OF INCLUSIVE GRAPHICAL USER INTERFACES

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Today, color vision deficiency (CVD) is not an isolated problem but a global challenge [1]. Approximately 8% of men and 0.4% of women suffer from various forms of color blindness, which amounts to over 300 million people worldwide. Despite technological advancements, most modern image correction software solutions rely on CPU-based computations. This has become a “bottleneck” because traditional sequential algorithms cannot keep up with processing high-definition video or live streams in real time, which significantly limits users [2].

The goal of this work is to accelerate the color conversion process for the subsequent implementation of improved methods in inclusive graphical user interfaces while preserving the clarity of interface details by adapting contrast for three forms of color blindness – protanopia, deuteranopia, and tritanopia–which is particularly critical when working with high resolutions ranging from HD to 4K.

The goal was achieved by leveraging the computational capabilities of massively parallel GPU architecture through a comparative analysis of three color conversion methods – per-pixel, matrix, and hybrid (the Machado transformation adapts the color gamut, while the CLAHE algorithm evens out the image histogram so that the image does not lose contrast or fine details after color adjustment), using the CuPy library and CUDA architecture [3]. This allowed data to be cached directly in video memory. It was shown that using CUDA reduces the processing time for a single 4K frame from over 80 seconds (when using a “pixel-by-pixel” algorithm on the CPU) to 0.23 seconds, while a hybrid approach on the GPU reduces this time even further–to 0.13 seconds. It was found that for the 4K format, the acceleration is approximately 12 times faster than the traditional matrix method on the CPU. The proposed hybrid approach is promising for inclusive systems, as it combines high performance with enhanced image information. Further avenues for developing this topic include researching the capabilities of neural networks to create personalized correction profiles for each specific user.

References

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